CHAPTER 4

WASTEWATER CHARACTERISTICS

4.1 Introduction

The effective management of any wastewater flow requires a reasonably accurate knowledge of its characteristics. This is particularly true for wastewater flows from rural residential dwellings, commercial establishments and other facilities where individual water-using activities create an intermittent flow of wastewater that can vary widely in volume and degree of pollution. Detailed characterization data regarding these flows are necessary not only to facilitate the effective design of wastewater treatment and disposal systems, but also to enable the development and application of water conservation and waste load reduction strategies.

For existing developments, characterization of the actual wastewaters to be encountered may often times be accomplished. However, for many existing developments, and for almost any new development, wastewater characteristics must be predicted. The purpose of this chapter is to provide a basis for characterizing the wastewater from rural developments. A detailed discussion of the characteristics of residential wastewaters is presented first, followed by a limited discussion of the characteristics of the wastewaters generated by nonresidential establishments, including those of a commercial, institutional and recreational nature. Finally, a general procedure for predicting wastewater characteristics for a given residential dwelling or nonresidential establishment is given.

4.2 Residential Wastewater Characteristics

Residential dwellings exist in a variety of forms, including single- and multi-family households, condominium homes, apartment houses and cottages or resort residences. In all cases, occupancy can occur on a seasonal or year-round basis. The wastewater discharged from these dwellings is comprised of a number of individual wastewaters, generated through water-using activities employing a variety of plumbing fixtures and appliances. The characteristics of the wastewater can be influenced by several factors. Primary influences are the characteristics of the plumbing fixtures and appliances present as well as their frequency of use. Additionally, the characteristics of the residing family in terms of number of family members, age levels, and mobility are important as is the overall socioeconomic status of the family. The characteristics of the dwelling itself, including seasonal or yearly occupancy, geographic location, and method of water supply and wastewater disposal, appear as additional, but lesser, influences.

4.2.1 Wastewater Flow

4.2.1.1 Average Daily Flow

The average daily wastewater flow from a typical residential dwelling is approximately 45 gal/capita/day (gpcd) (170 liters/capita/day [lpcd]) (Table 4-1). While the average daily flow experienced at one residence compared to that of another can vary considerably, it is typically no greater than 60 gpcd (227 lpcd) and seldom exceeds 75 gpcd (284 lpcd) (Figure 4-1).

4.2.1.2 Individual Activity Flows

The individual wastewater generating activities within a residence are the building blocks that serve to produce the total residential wastewater discharge. The average characteristics of several major residential water-using activities are presented in Table 4-2. A water-using activity that falls under the category of miscellaneous in this table, but deserves additional comment, is water-softener backwash/regeneration flows. Water softener regeneration typically occurs once or twice a week, discharging about 30-88 gal (114 to 333 l) per regeneration cycle (11). On a daily per capita basis, water softener flows have been shown to average about 5 gpcd (19 lpcd), ranging from 2.3 to 15.7 gpcd (8.7 to 59.4 lpcd) (7).

4.2.1.3 Wastewater Flow Variations

The intermittent occurrence of individual wastewater-generating activities creates large variations in the wastewater flow rate from a residence.

a. Minimum and Maximum Daily Flows

The daily wastewater flow from a specific residential dwelling is typically within 10% and 300% of the average daily flow at that dwelling, with the vast majority within 50 and 150% of the average day. At the

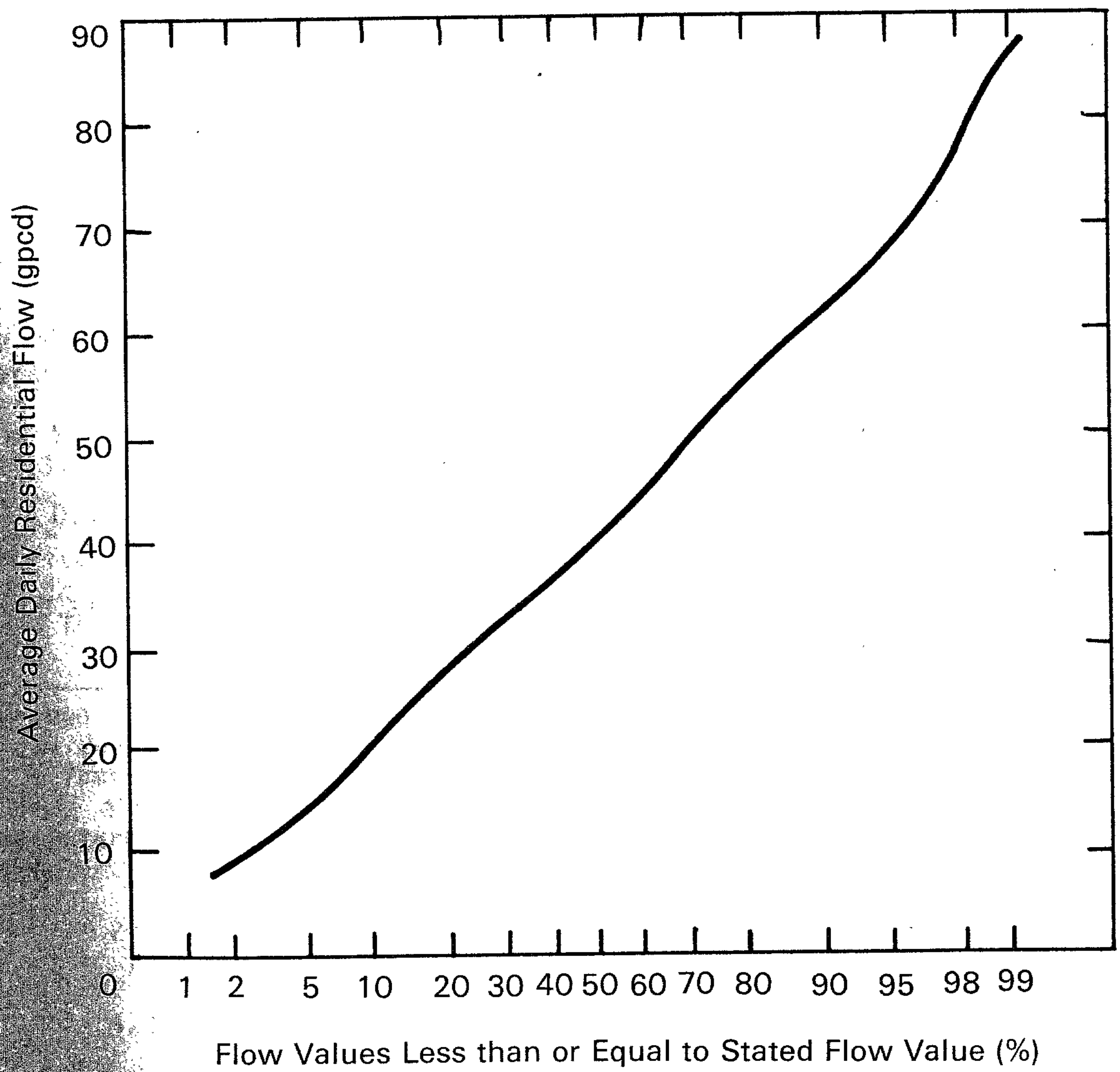
TABLE 4-1

SUMMARY OF AVERAGE DAILY RESIDENTIAL WASTEWATER FLOWS

Study	No. of Residences	Duration of Study months	Wastewater Flow Study Average gpcd	Wastewater Flow Range of Individual Residence Averages gpcd
Linaweaver, et al. (1)	22	-	49	36 - 66
Anderson and Watson (2)	18	4	44	18 - 69
Watson, et al. (3)	3	2-12	53	25 - 65
Cohen and Wallman (4)	8	6	52	37.8 - 101.6
Laak (5)	5	24	41.4	26.3 - 65.4
Bennett and Linstedt (6)	5	0.5	44.5	31.8 - 82.5
Siegrist, et al. (7)	11	1	42.6	25.4 - 56.9
Otis (8)	21	12	36	8 - 71
Duffy, et al. (9)	16	12	42.3	-
		Weighted Average	44	

FIGURE 4-1

FREQUENCY DISTRIBUTION FOR AVERAGE DAILY RESIDENTIAL WATER USE/WASTE FLOWS



Note: Based on the average daily flow measured for each of the 71 residences studied in (2) (3) (4) (5) (6) (7) (8).

TABLE 4-2

RESIDENTIAL WATER USE BY ACTIVITY[a]

Activity	Gal/use	Uses/cap/day	gpcd[b]
Toilet Flush	4.3 4.0 - 5.0	3.5 2.3 - 4.1	16.2 9.2 - 20.0
Bathing	24.5 21.4 - 27.2	0.43 0.32 - 0.50	9.2 6.3 - 12.5
Clotheswashing	37.4 33.5 - 40.0	0.29 0.25 - 0.31	10.0 7.4 - 11.6
Dishwashing	8.8 7.0 - 12.5	0.35 0.15 - 0.50	3.2 1.1 - 4.9
Garbage Grinding	2.0 2.0 - 2.1	0.58 0.4 - 0.75	1.2 0.8 - 1.5
Miscellaneous	-	-	6.6 5.7 - 8.0
Total	-	-	45.6 41.4 - 52.0

[a] Mean and ranges of results reported in (4)(5)(6)(7)(10).

[b] gpcd may not equal gal/use multiplied by uses/cap/day due to difference in the number of study averages used to compute the mean and ranges shown.

extreme, however, minimum and maximum daily flows of 0% and 900% of the average daily flow may be encountered (2)(3)(12).

b. Minimum and Maximum Hourly Flows

Minimum hourly flows of zero are typical. Maximum hourly flows are more difficult to quantify accurately. Based on typical fixture and appliance usage characteristics, as well as an analysis of residential water usage demands, maximum hourly flows of 100 gal/hr (380 l/hr) can occur (2)(13). Hourly flows in excess of this can occur due to plumbing fixture and appliance misuse or malfunction (e.g., faucet left on or worn toilet tank flapper).

c. Instantaneous Peak Flows

The peak flow rate from a residential dwelling is a function of the characteristics of the fixtures and appliances present and their position in the overall plumbing system layout. The peak discharge rate from a given fixture/appliance is typically around 5 gal/minute (gpm) (0.3 liters/sec), with the exception of the tank-type water closet which discharges at a peak flow of up to 25 gpm (1.6 l/sec). The use of several fixtures/appliances simultaneously can increase the total flow rate from the isolated fixtures/appliances. However, attenuation occurring in the residential drainage network tends to decrease the peak flow rates in the sewer exiting the residence.

Although field data are limited, peak discharge rates from a single-family dwelling of 5 to 10 gpm (0.3 to 0.6 l/sec) can be expected. For multi-family units, peak rates in excess of these values commonly occur. A crude estimate of the peak flow in these cases can be obtained using the fixture-unit method described in Section 4.3.1.2.

4.2.2 Wastewater Quality

4.2.2.1 Average Daily Flow

The characteristics of typical residential wastewater are outlined in Table 4-3, including daily mass loadings and pollutant concentrations. The wastewater characterized is typical of residential dwellings equipped with standard water-using fixtures and appliances (excluding garbage disposals) that collectively generate approximately 45 gpcd (170 lpcd).

TABLE 4-3

CHARACTERISTICS OF TYPICAL RESIDENTIAL WASTEWATER[a]

Parameter	Mass Loading gm/cap/day	Concentration mg/l
Total Solids	115 - 170	680 - 1000
Volatile Solids	65 - 85	380 - 500
Suspended Solids	35 - 50	200 - 290
Volatile Suspended Solids	25 - 40	150 - 240
BOD_5	35 - 50	200 - 290
Chemical Oxygen Demand	115 - 125	680 - 730
Total Nitrogen	6 - 17	35 - 100
Ammonia	1 - 3	6 - 18
Nitrites and Nitrates	<1	<1
Total Phosphorus	3 - 5	18 - 29
Phosphate	1 - 4	6 - 24
Total Coliforms[b]	-	10^{10} - 10^{12}
Fecal Coliforms[b]	-	10^{8} - 10^{10}

[a] For typical residential dwellings equipped with standard water-using fixtures and appliances (excluding garbage disposals) generating approximately 45 gpcd (170 lpcd). Based on the results presented in (5)(6)(7)(10)(13).

[b] Concentrations presented in organisms per liter.

4.2.2.2 Individual Activity Contributions

Residential water-using activities contribute varying amounts of pollutants to the total wastewater flow. The individual activities may be grouped into three major wastewater fractions: (1) garbage disposal wastes, (2) toilet wastes, and (3) sink, basin, and appliance wastewaters. A summary of the average contribution of several key pollutants in each of these three fractions is presented in Tables 4-4 and 4-5.

With regard to the microbiological characteristics of the individual waste fractions, studies have demonstrated that the wastewater from sinks, basins, and appliances can contain significant concentrations of indicator organisms as total and fecal coliforms (14)(15)(16)(17). Traditionally, high concentrations of these organisms have been used to assess the contamination of a water or wastewater by pathogenic organisms. One assumes, therefore, that these wastewaters possess some potential for harboring pathogens.

4.2.2.3 Wastewater Quality Variations

Since individual water-using activities occur intermittently and contribute varying quantities of pollutants, the strength of the wastewater generated from a residence fluctuates with time. Accurate quantification of these fluctuations is impossible. An estimate of the type of fluctuations possible can be derived from the pollutant concentration information presented in Table 4-5 considering that the activities included occur intermittently.

4.3 Nonresidential Wastewater Characteristics

The rural population, as well as the transient population moving through the rural areas, is served by a wide variety of isolated commercial establishments and facilities. For many establishments, the wastewater-generating sources are sufficiently similar to those in a residential dwelling that residential wastewater characteristics can be applied. For other establishments, however, the wastewater characteristics can be considerably different from those of a typical residence.

Providing characteristic wastewater loadings for "typical" non-residential establishments is a very complex task due to several factors. First, there is a relatively large number of diverse establishment categories (e.g., bars, restaurants, drive-in theaters, etc.). The inclusion of potentially diverse establishments within the same category produces a potential for large variations in waste-generating sources

TABLE 4-4

POLLUTANT CONTRIBUTIONS OF MAJOR RESIDENTIAL WASTEWATER FRACTIONS[a] (gm/cap/day)

Parameter	Garbage Disposal	Toilet	Basins, Sinks, Appliances	Approximate Total
BOD_5	18.0 10.9 - 30.9	16.7 6.9 - 23.6	28.5 24.5 - 38.8	63.2
Suspended Solids	26.5 15.8 - 43.6	27.0 12.5 - 36.5	17.2 10.8 - 22.6	70.7
Nitrogen	0.6 0.2 - 0.9	8.7 4.1 - 16.8	1.9 1.1 - 2.0	11.2
Phosphorus	0.1 0.1 - 0.1	1.2 0.6 - 1.6	2.8 2.2 - 3.4	4.0

[a] Means and ranges of results reported in (5)(6)(7)(10)(14)

TABLE 4-5

POLLUTANT CONCENTRATIONS OF MAJOR RESIDENTIAL WASTEWATER FRACTIONS[a] (mg/l)

Parameter	Garbage Disposal	Toilet	Basins, Sinks, Appliances	Combined Wastewater
BOD_5	2380	280	260	360
Suspended Solids	3500	450	160	400
Nitrogen	79	140	17	63
Phosphorus	13	20	26	23

[a] Based on the average results presented in Table 4-4 and the following wastewater flows: Garbage disposal - 2 gpcd (8 lpcd); toilet - 16 gpcd (61 lpcd); basins, sinks and appliances - 29 gpcd (110 lpcd); total - 47 gpcd (178 lpcd).

and the resultant wastewater characteristics. Further, many intangible influences such as location, popularity, and price may produce substantial wastewater variations between otherwise similar establishments. Finally, there is considerable difficulty in presenting characterization data in units of measurement that are easy to apply, yet predictively accurate. (For example, at a restaurant, wastewater flow in gal/seat is easy to apply to estimate total flow, but is less accurate than if gal/meal served were used.)

In this section, limited characterization data for nonresidential establishments, including commercial establishments, institutional facilities, and recreational areas, are presented. These data are meant to serve only as a guide, and as such should be applied cautiously. Wherever possible, characterization data for the particular establishment in question, or a similar one in the vicinity, should be obtained.

4.3.1 Wastewater Flow

4.3.1.1 Average Daily Flow

Typical daily flows from a variety of commercial, institutional, and recreational establishments are presented in Tables 4-6 to 4-8.

4.3.1.2 Wastewater Flow Variation

The wastewater flows from nonresidential establishments are subject to wide fluctuations with time. While difficult to quantify accurately, an estimate of the magnitude of the fluctuations, including minimum and maximum flows on an hourly and daily basis, can be made if consideration is given to the characteristics of the water-using fixtures and appliances, and to the operational characteristics of the establishment (hours of operation, patronage fluctuations, etc.).

Peak wastewater flows can be estimated utilizing the fixture-unit method (19)(20). As originally developed, this method was based on the premise that under normal usage, a given type of fixture had an average flow rate and duration of use (21)(22). One fixture unit was arbitrarily set equal to a flow rate of 7.5 gpm (0.5 l/sec), and various fixtures were assigned a certain number of fixture units based upon their particular characteristics (Table 4-9). Based on probability studies, relationships were developed between peak water use and the total number of fixture units present (Figure 4-2).

TABLE 4-6

TYPICAL WASTEWATER FLOWS FROM COMMERCIAL SOURCES (18)

Source	Unit	Wastewater Flow Range gpd/unit	Wastewater Flow Typical gpd/unit
Airport	Passenger	2.1 - 4.0	2.6
Automobile Service Station	Vehicle Served	7.9 - 13.2	10.6
	Employee	9.2 - 15.8	13.2
Bar	Customer	1.3 - 5.3	2.1
	Employee	10.6 - 15.8	13.2
Hotel	Guest	39.6 - 58.0	50.1
	Employee	7.9 - 13.2	10.6
Industrial Building (excluding industry and cafeteria)	Employee	7.9 - 17.2	14.5
Laundry (self-service)	Machine	475 - 686	580
	Wash	47.5 - 52.8	50.1
Motel	Person	23.8 - 39.6	31.7
Motel with Kitchen	Person	50.2 - 58.1	52.8
Office	Employee	7.9 - 17.2	14.5
Restaurant	Meal	2.1 - 4.0	2.6
Rooming House	Resident	23.8 - 50.1	39.6
Store, Department	Toilet room	423 - 634	528
	Employee	7.9 - 13.2	10.6
Shopping Center	Parking Space	0.5 - 2.1	1.1
	Employee	7.9 - 13.2	10.6

TABLE 4-7

TYPICAL WASTEWATER FLOWS FROM INSTITUTIONAL SOURCES (18)

Source	Unit	Wastewater Flow Range (gpd/unit)	Wastewater Flow Typical (gpd/unit)
Hospital, Medical	Bed	132 - 251	172
	Employee	5.3 - 15.9	10.6
Hospital, Mental	Bed	79.3 - 172	106
	Employee	5.3 - 15.9	10.6
Prison	Inmate	79.3 - 159	119
	Employee	5.3 - 15.9	10.6
Rest Home	Resident	52.8 - 119	92.5
	Employee	5.3 - 15.9	10.6
School, Day:			
With Cafeteria, Gym, Showers	Student	15.9 - 30.4	21.1
With Cafeteria Only	Student	10.6 - 21.1	15.9
Without Cafeteria, Gym, Showers	Student	5.3 - 17.2	10.6
School, Boarding	Student	52.8 - 106	74.0

TABLE 4-8

TYPICAL WASTEWATER FLOWS FROM RECREATIONAL SOURCES (18)

Source	Unit	Wastewater Flow gpd/unit Range	Wastewater Flow gpd/unit Typical
Apartment, Resort	Person	52.8 - 74	58.1
Cabin, Resort	Person	34.3 - 50.2	42.3
Cafeteria	Customer	1.1 - 2.6	1.6
	Employee	7.9 - 13.2	10.6
Campground (developed)	Person	21.1 - 39.6	31.7
Cocktail Lounge	Seat	13.2 - 26.4	19.8
Coffee Shop	Customer	4.0 - 7.9	5.3
	Employee	7.9 - 13.2	10.6
Country Club	Member Present	66.0 - 132	106
	Employee	10.6 - 15.9	13.2
Day Camp (no meals)	Person	10.6 - 15.9	13.2
Dining Hall	Meal Served	4.0 - 13.2	7.9
Dormitory, Bunkhouse	Person	19.8 - 46.2	39.6
Hotel, resort	Person	39.6 - 63.4	52.8
Laundromat	Machine	476 - 687	581
Store Resort	Customer	1.3 - 5.3	2.6
	Employee	7.9 - 13.2	10.6
Swimming Pool	Customer	5.3 - 13.2	10.6
	Employee	7.9 - 13.2	10.6
Theater	Seat	2.6 - 4.0	2.6
Visitor Center	Visitor	4.0 - 7.9	5.3

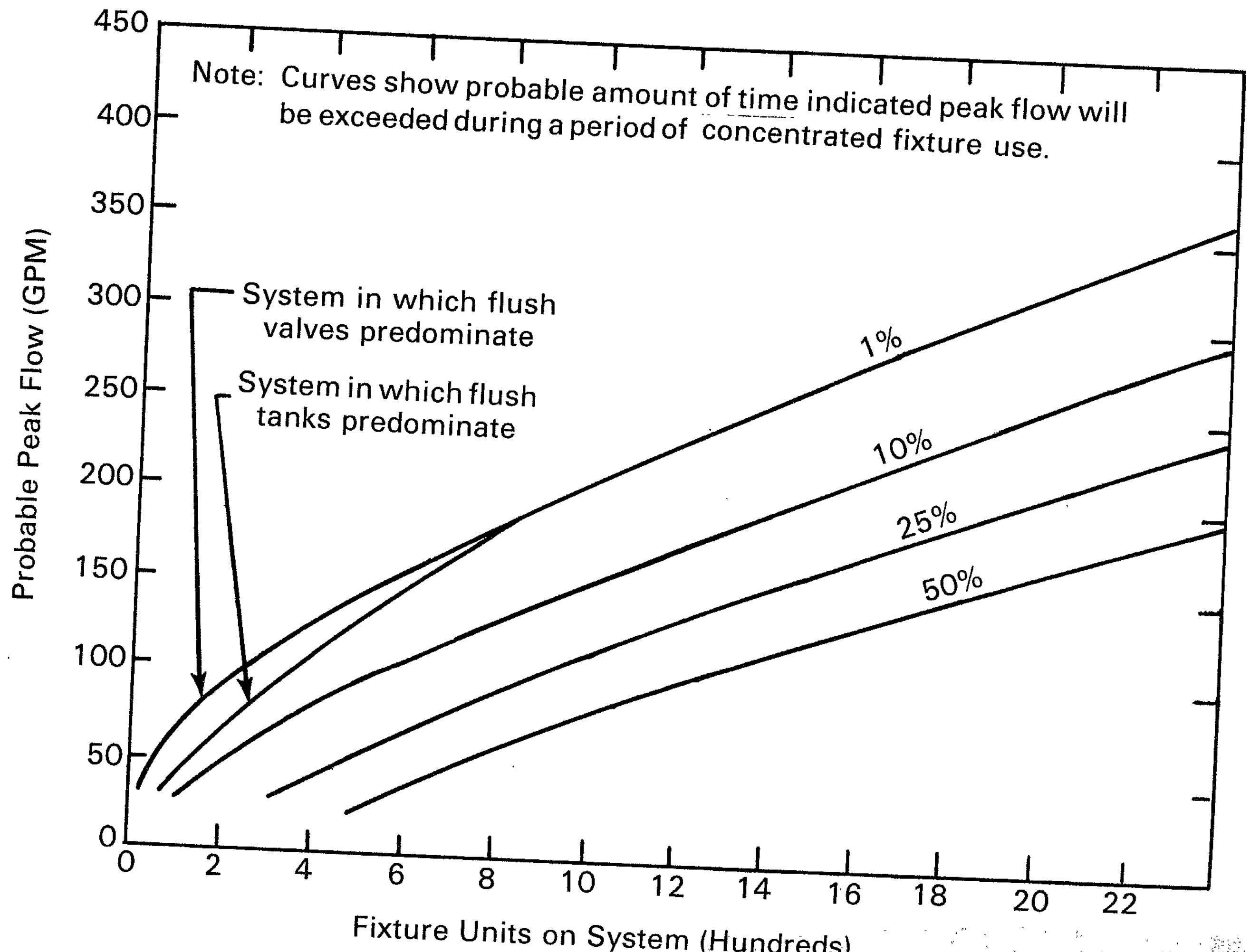
TABLE 4-9

FIXTURE-UNITS PER FIXTURE (19)

Fixture Type	Fixture-Units
One bathroom group consisting of tank-operated water closet, lavatory, and bathtub or shower stall	6
Bathtub (with or without overhead shower)	2
Bidet	3
Combination sink-and-tray	3
Combination sink-and-tray with food-disposal unit	4
Dental unit or cuspidor	1
Dental lavatory	1
Drinking fountain	1/2
Dishwasher, domestic	2
Floor drains	1
Kitchen sink, domestic	2
Kitchen sink, domestic, with food waste grinder	3
Lavatory	1
Lavatory	2
Lavatory, barber, beauty parlor	2
Lavatory, surgeon's	2
Laundry tray (1 or 2 compartments)	2
Shower stall, domestic	2
Showers (group) per head	3
Sinks	
Surgeon's	3
Flushing rim (with valve)	8
Service (trap standard)	3
Service (P trap)	2
Pot, scullery, etc.	4
Urinal, pedestal, syphon jet, blowout	8
Urinal, wall lip	4
Urinal stall, washout	4
Urinal trough (each 2-ft section)	2
Wash sink (circular or multiple) each set of faucets	2
Water closet, tank-operated	4
Water closet, valve-operated	8

FIGURE 4-2

PEAK DISCHARGE VERSUS FIXTURE UNITS PRESENT (22)



4.3.2 Wastewater Quality

The qualitative characteristics of the wastewaters generated by nonresidential establishments can vary significantly between different types of establishments due to the extreme variation which can exist in the waste generating sources present. Consideration of the waste-generating sources present at a particular establishment can give a general idea of the character of the wastewater, and serve to indicate if the wastewater will contain any problem constituents, such as high grease levels from a restaurant or lint fibers in a laundromat wastewater.

If the waste-generating sources present at a particular establishment are similar to those typical of a residential dwelling, an approximation of the pollutant mass loadings and concentrations of the wastewater produced may be derived using the residential wastewater quality data presented in Tables 4-3 to 4-5. For establishments where the waste-generating sources appear significantly different from those in a residential dwelling, or where more refined characterization data are desired, a detailed review of the pertinent literature, as well as actual wastewater sampling at the particular or a similar establishment, should be conducted.

4.4 Predicting Wastewater Characteristics

4.4.1 General Considerations

4.4.1.1 Parameter Design Units

In characterizing wastewaters, quantitative and qualitative characteristics are often expressed in terms of other parameters. These parameter design units, as they may be called, vary considerably depending on the type of establishment considered. For residential dwellings, daily flow values and pollutant contributions are expressed on a per person (capita) basis. Applying per capita data to predict total residential wastewater characteristics requires that a second parameter be considered, namely, the number of persons residing in the residence. Residential occupancy typically ranges from 1.0 to 1.5 persons per bedroom. Although it provides for a conservative estimate, the current practice is to assume that maximum occupancy is two persons per bedroom.

For nonresidential establishments, wastewater characteristics are expressed in terms of a variety of units. Although per capita units are employed, a physical characteristic of the establishment, such as per seat, per car stall, or per square foot, is more commonly used.

4.4.1.2 Factors of Safety

To account for the potential variability in the wastewater characteristics at a particular dwelling or establishment, versus that of the average, conservative predictions or factors of safety are typically utilized. These factors of safety can be applied indirectly, through choice of the design wastewater characteristics and the occupancy patterns, as well as directly through an overall factor. For example, if an average daily flow of 75 gpcd (284 lpcd) and an occupancy of two persons per bedroom were selected, the flow prediction for a three-bedroom home would include a factor of safety of approximately 3 when compared to average conditions (i.e., 45 gpcd [170 lpcd] and 1 person per bedroom). If a direct factor of safety were also applied (e.g., 1.25), the total factor of safety would increase to approximately 3.75.

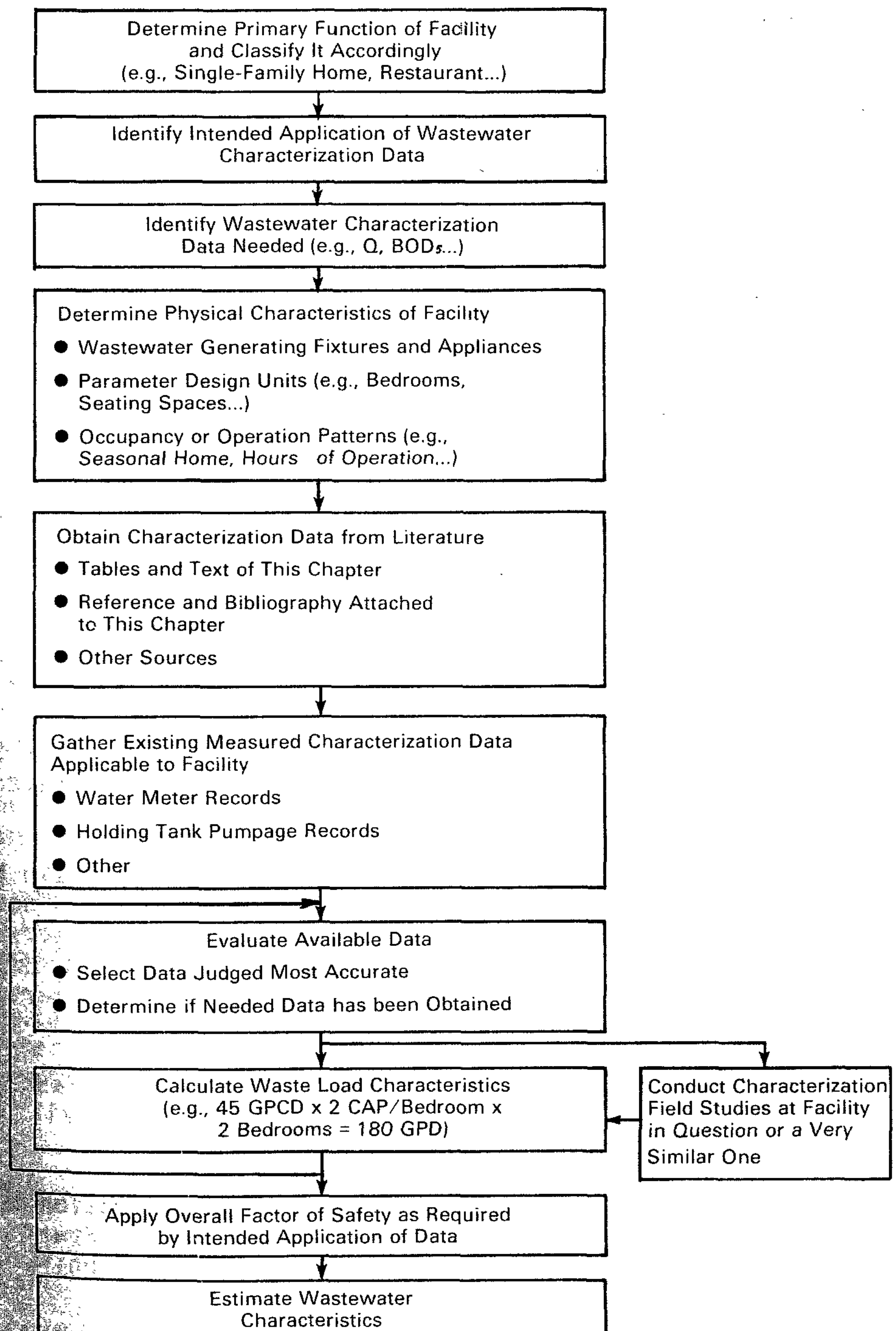
Great care must be exercised in predicting wastewater characteristics so as not to accumulate multiple factors of safety which would yield an extremely overconservative estimate.

4.4.2 Strategy for Predicting Wastewater Characteristics

Predicting wastewater characteristics from rural developments can be a complex task. Following a logical step-by-step procedure can help simplify the characterization process and render the estimated wastewater characteristics more accurate. A flow chart detailing a procedure for predicting wastewater characteristics is presented in Figure 4-3.

FIGURE 4-3

STRATEGY FOR PREDICTING WASTEWATER CHARACTERISTICS



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CHAPTER 5

WASTEWATER MODIFICATION

5.1 Introduction

The characteristics of the influent wastewater can have a major impact on most any onsite treatment and disposal/reuse system. To enhance conventional strategies, and to encourage new ones, methods can be used to modify the typical characteristics of the influent wastewater.

Methods for wastewater modification have been developed as part of three, basic interrelated strategies: water conservation and wastewater flow reduction, pollutant mass reduction, and onsite containment for offsite disposal. Each strategy attempts to reduce the flow volume or to decrease the mass of key pollutants such as oxygen-demanding substances, suspended solids, nutrients, and pathogenic organisms in the influent wastewater to the onsite disposal system.

Although the primary thrust of this chapter is directed toward residential dwellings, many of the concepts and techniques presented have equal or even greater application to nonresidential establishments. Good practice dictates that water conservation/flow reduction be employed to the maximum extent possible in a dwelling served by an onsite wastewater system.

At the onset, there are several general considerations regarding wastewater modification. First, there are a number of methods available, including a wide variety of devices, fixtures, appliances, and systems. Further, the number of methods and the diversity of their characteristics is ever growing. In many cases, the methods involve equipment manufactured by one or more companies as proprietary products. In this chapter, only generic types of these products are considered. Also, many methods and system components are presently in various stages of development and/or application; therefore, only preliminary or projected operation and performance information may be available. Finally, the characteristics of many of the methods discussed may result in their nonconformance with existing local plumbing codes.

5.2 Water Conservation and Wastewater Flow Reduction

An extensive array of techniques and devices are available to reduce the average water use and concomitant wastewater flows generated by individual water-using activities and, in turn, the total effluent from the residence or establishment. The diversity of present wastewater flow reduction methods is illustrated in Table 5-1. As shown, the methods may be divided into three major groups: (1) elimination of nonfunctional water use, (2) water-saving devices, fixtures, and appliances; and (3) wastewater recycle/reuse systems.

5.2.1 Elimination of Nonfunctional Water Use

Wasteful water use habits can occur with most water-using activities. A few illustrative examples include using a toilet flush to dispose of a cigarette butt, allowing the water to run while brushing teeth or shaving, or operating a clothes washer or dishwasher with only a partial load. Obviously, the potential for wastewater flow reductions through elimination of these types of wasteful use vary tremendously between homes, from minor to significant reductions, depending on existing habits.

5.2.1.1 Improved Plumbing and Appliance Maintenance

Unseen or apparently insignificant leaks from household fixtures and appliances can waste large volumes of water and generate similar quantities of wastewater. Most notable in this regard are leaking toilets and dripping faucets. For example, a steadily dripping faucet can waste up to several hundred gallons per day.

5.2.1.2 Maintain Nonexcessive Water Supply Pressure

The water flow rate through sink and basin faucets, showerheads, and similar fixtures is highly dependent on the water pressure in the water supply line. For most residential uses, a pressure of 40 psi (2.8 kg/cm^2) is adequate. Pressure in excess of this can result in unnecessary water use and wastewater generation. To illustrate, the flow rate through a typical faucet opened fully is about 40% higher at a supply pressure of 80 psi (5.6 kg/cm^2) versus that at 40 psi (2.8 kg/cm^2).

TABLE 5-1

EXAMPLE WASTEWATER FLOW REDUCTION METHODS

I. Elimination of Nonfunctional Water Use
  - A. Improved water use habits
  - B. Improved plumbing and appliance maintenance
  - C. Nonexcessive water supply pressure

II. Water-Saving Devices, Fixtures, and Appliances
  - A. Toilet
    - 1. Water carriage toilets
      - a. Toilet tank inserts
      - b. Dual-flush toilets
      - c. Water-saving toilets
      - d. Very low-volume flush toilets
        - (1) Wash-down flush
        - (2) Mechanically assisted
          - o Pressurized tank
          - o Compressed air
          - o Vacuum
          - o Grinder
    - 2. Non-water carriage toilets
      - a. Pit privies
      - b. Composting toilets
      - c. Incinerator toilets
      - d. Oil-carriage toilets
  - B. Bathing devices, fixtures, and appliances
    - 1. Shower flow controls
    - 2. Reduced-flow showerheads
    - 3. On/Off showerhead valves
    - 4. Mixing valves
    - 5. Air-assisted low-flow shower system
  - C. Clotheswashing devices, fixtures, and appliances
    - 1. Front-loading washer
    - 2. Adjustable cycle settings
    - 3. Washwater recycle feature
  - D. Miscellaneous
    - 1. Faucet inserts
    - 2. Faucet aerators
    - 3. Reduced-flow faucet fixtures
    - 4. Mixing valves
    - 5. Hot water pipe insulation
    - 6. Pressure-reducing valves

III. Wastewater Recycle/Reuse Systems
  - A. Bath/Laundry wastewater recycle for toilet flushing
  - B. Toilet wastewater recycle for toilet flushing
  - C. Combined wastewater recycle for toilet flushing
  - D. Combined wastewater recycle for several uses

5.2.2 Water-Saving Devices, Fixtures, and Appliances

The quantity of water traditionally used by a given water-using fixture or appliance is often considerably greater than actually needed. Certain tasks may even be accomplished without the use of water. As presented in Table 4-2, over 70% of a typical residential dwelling's wastewater flow volume is collectively generated by toilet flushing, bathing, and clotheswashing. Thus, efforts to accomplish major wastewater flow reductions should be directed toward these three activities.

5.2.2.1 Toilet Devices and Systems

Each flush of a conventional water-carriage toilet uses between 4 and 7 gal (15 and 26 l) of water depending on the model and water supply pressure. On the average, a typical flush generates approximately 4.3 gal (16 l) of wastewater. When coupled with 3.5 uses/cap/day, a daily wastewater flow of approximatley 16 gpcd (61 lpcd) results (Table 4-2).

A variety of devices have been developed for use with a conventional flush toilet to reduce the volume of water used in flushing. Additionally, alternatives to the conventional water-carriage toilet are available, certain of which use little or no water to transport human wastewater products. Tables 5-2 and 5-3 present a summary of a variety of toilet devices and systems. Additional details regarding the non-water carriage toilets may be found elsewhere (1)(2)(3)(4)(5).

5.2.2.2 Bathing Devices and Systems

Although great variation exists in the quantity of wastewater generated by a bath or shower, typical values include approximatley 25 gal (95 l) per occurrence coupled with a 0.4 use/capita/day frequency to yield a daily per capita flow of about 10 gal (38 l) (Table 4-2). The majority of devices available to reduce bathing wastewater flow volumes are concentrated around the activity of showering, with their objective being to reduce normal 4- to 10-gal/min (0.25 to 0.63 l/sec) showering flow rate. Several flow reduction devices and systems for showering are characterized in Table 5-4. The amount of total wastewater flow reduction accomplished with these devices is highly dependent on individual user habits. Reductions vary from a negative value to as much as 12% of the total wastewater volume.

TABLE 5-2

WASTEWATER FLOW REDUCTION - WATER CARRIAGE TOILETS AND SYSTEMS

Generic Type	Description	Development Stage[a]	Application Considerations	Operation and Maintenance	Water Use Per Event gal	Total Flow Reduction[b] gpcd	Total Flow Reduction[b] %
Toilet with Tank Inserts	Displacement devices placed into storage tank of conventional toilets to reduce volume but not height of stored water. Varieties: Plastic bottles, flexible panels, drums or plastic bags.	4-5	Device must be compatible with existing toilet and not interfere with flush mechanism. Installation by owner.	Post-installation and periodic inspections to insure proper positioning.	3.3-3.8	1.8-3.5	4-8
Dual Flush Toilets	Devices made for use with conventional flush toilets; enable user to select from two or more flush volumes based on solid or liquid waste materials. Varieties: Many	3	Device must be compatible with existing toilet and not interfere with flush mechanism. Installation by owner.	Post-installation and periodic inspections to insure proper positioning and functioning.	2.5-4.3	3.0-7.0	6-15
Water-Saving Toilets	Variation of conventional flush toilet fixture; similar in appearance and operation. Redesigned flushing rim and priming jet to initiate siphon flush in smaller trapway with less water. Varieties: Many manufacturers but units similar.	5	Interchangeable with conventional fixture. Requires pressurized water supply.	Essentially the same as for a conventional unit.	3.0-3.5	2.8-4.6	6-10

TABLE 5-2 (continued)

Generic Type	Description	Development Stage[a]	Application Considerations	Operation and Maintenance	Water Use Per Event gal	Total Flow Reduction[b] gpcd	Total Flow Reduction[b] %
Washdown Flush Toilets	Flushing uses only water, but substantially less due to washdown flush. Varieties: Few.	3-4	Rough-in for unit may be nonstandard. Drain line slope and lateral run restrictions. Requires pressurized water supply.	Similar to conventional toilet, but more frequent cleaning possible.	0.8-1.6	9.4-12.2	21-27
Pressurized Tank	Specially designed toilet tank to pressurize air contained in toilet tank. Upon flushing, the compressed air propels water into bowl at increased velocity. Varieties: Few.	3	Compatible with most any conventional toilet unit. Increased noise level. Water supply pressure of 35 to 120 psi.	Similar to conventional toilet fixture.	2.0-2.5	6.3-8.0	14-18
Compressed Air-Assisted Flush Toilets	Similar in appearance and user operation to conventional toilet; specially designed to utilize compressed air to aid in flushing. Varieties: Few	3-4	Interchangeable with rough-in for conventional fixture. Requires source of compressed air; bottled or air compressor. If air compressor, need power source.	Periodic maintenance of compressed air source. Power use - 0.002 KwH per use.	0.5	13.3	30

TABLE 5-2 (continued)

Generic Type	Description	Development Stage[a]	Application Considerations	Operation and Maintenance	Water Use Per Event gal	Total Flow Reduction[b] gpcd	Total Flow Reduction[b] %
Vacuum-Assisted Flush Toilets	Similar in appearance and user operation to conventional toilet; specially designed fixture is connected to vacuum system which assists a small volume of water in flushing. Varieties: Several.	3	Application largely for multi-unit toilet installations Above floor, rear discharge. Drain pipe may be horizontal or inclined. Requires vacuum pump. Requires power source.	Periodic maintenance of vacuum pump. Power use = 0.002 KwH per use.	0.3	14	31

a 1 = Prototype developed and under evaluation.
2 = Development complete, commercial production initiated, not locally available.
3 = Fully developed, limited use, not locally available, mail order purchase likely.
4 = Fully developed, limited use, locally available from plumbing supply houses or hardware stores.
5 = Fully developed, widespread use, locally available from plumbing supply houses or hardware stores.

b Compared to conventional toilet usage (4.3 gal/flush, 3.5 uses/cap/day, and a total daily flow of 45 gpcd)

TABLE 5-3

WASTEWATER FLOW REDUCTION - NON-WATER CARRIAGE TOILETS

Generic Type[a]	Description	Development Stage[b]	Application Considerations	Operation and Maintenance
Pit Privy	Hand-dug hole in the ground covered with a squatting plate or stool/seat with an enclosing house. May be sealed vault rather than dug hole.	4	Requires same site conditions as for wastewater disposal (see Chapter 8), unless sealed vault. Handles only toilet wastes Outdoor installation. May be constructed by user.	When full, cover with 2 ft of soil and construct new pit.
Composting Privy	Similar to pit privy except organic matter is added after each use. When pit is full it is allowed to compost for a period of about 12 months prior to removal and use as soil amendment.	4	Can be constructed independent of site conditions if sealed vault. Handles only toilet waste and garbage. May be constructed by user. Outdoor installation. Residuals disposal.	Addition of organic matter after each use. Removal and disposal/reuse of composted material.
Composting-Small	Small self-contained units accept toilet wastes only and utilize the addition of heat in combination with aerobic biological activity to stabilize human excreta. Varieties: Several.	3-4	Installation requires 4-in. diameter roof vent. Handles only toilet waste. Set usage capacity. Power required. Residuals disposal.	Removal and disposal of composted material quarterly. Power use = 2.5 KwH/day. Heat loss through vent.
Composting-Large	Larger units with a separated decomposition chamber. Accept toilet wastes and other organic matter, and over a long time period stabilize excreta through biological activity. Varieties: Several	3-4	Installation requires 6- to 12-in. diameter roof vent and space beneath floor for decomposition chamber. Handles toilet waste and some kitchen waste. Set usage capacity. May be difficult to retrofit. Residuals disposal.	Periodic addition of organic matter. Removal of composted material at 6 to 24 month intervals. Power use = 0.3 to 1.2 KwH/day. Heat loss through vent.

TABLE 5-3 (continued)

Generic Type[a]	Description	Development Stage[b]	Application Considerations	Operation and Maintenance
Incinerator	Small self-contained units which volatilize the organic components of human waste and evaporate the liquids. Varieties: Several.	3	Installation requires 4-in. diameter roof vent. Handles only toilet waste. Power or fuel required. Increased noise level. Residuals disposal.	Weekly removal of ash. Semiannual cleaning and adjustment of burning assembly and/or heating elements. Power use = 1.2 KwH or 0.3 lb LP gas per use.
Oil Recycle	Systems use a mineral oil to transport human excreta from a fixture (similar in appearance and use to conventional) to a storage tank. Oil is purified and reused for flushing. Varieties: few.	2	Requires separate plumbing for toilet fixture. May be difficult to retrofit. Handles only toilet wastes Residuals disposal.	Yearly removal and disposal of excreta in storage tank. Yearly maintenance of oil purification system by skilled technician. Power use = 0.01 KwH/use.

[a] None of these devices uses any water; therefore, the amount of flow reduction is equal to the amount of conventional toilet use: 16.2 gpcd or 36% of normal daily flow (45 gpcd). Significant quantities of pollutants (including N, BOD_5, SS, P and pathogens) are therefore removed from wastewater stream.

[b] 1 = Prototype developed and under evaluation.
2 = Development complete; commercial production initiated, but distribution may be restricted; mail order purchase.
3 = Fully developed; limited use, not locally available; mail order purchase likely.
4 = Fully developed; limited use, available form local plumbing supply houses or hardware stores.
5 = Fully developed; widespread use, available from local plumbing supply houses or hardware stores.

TABLE 5-4

WASTEWATER FLOW REDUCTION - BATHING DEVICES AND SYSTEMS

Generic Type[a]	Description	Development Stage[b]	Application Considerations	Water Use gal/min
Shower Flow Control Inserts and Restrictors	Reduce flow rate by reducing the diameter of supply line ahead of shower head. Varieties: Many.	4	Compatible with most existing showerheads. Installed by user.	1.5-3.0
Reduced-Flow Showerheads	Fixtures similar to conventional, except restrict flow rate. Varieties: Many manufacturers, but units similar.	4-5	Can match to most plumbing fixture appearance schemes. Compatible with most conventional plumbing.	1.5-3.0
ON/OFF Showerhead Valve	Small valve device placed in the supply line ahead of showerhead, allows shower flow to be turned ON/OFF without readjustment of volume or temperature.	4	Compatible with most conventional plumbing and fixtures. May be installed by user.	---
Thermostat-ically Controlled Mixing Valve	Specifically designed valve controls temperature of total flow according to predetermined setting. Valve may be turned ON/OFF without readjustment.	3	May be difficult to retrofit.	---

TABLE 5-4 (continued)

Generic Type[a]	Description	Development Stage[b]	Application Considerations	Water Use gal/min
Pressure-Balanced Mixing Valve	Specifically designed valve maintains constant temperature of total flow regardless of pressure changes. Single control allows temperature to be preset.	4	Compatible with most conventional plumbing and fixtures.	---
Air-Assisted Low-Flow Shower System	Specifically designed system uses compressed air to atomize water flow and provide shower sensation.	2	May be impossible to retrofit. Shower location < 50 feet of water heater. Requires compressed air source. Power source required. Maintenance of air compressor. Power use = 0.01 KwH/use.	0.5

[a] No reduction in pollutant mass; slight increase in pollutant concentration.

[b] 1 = Prototype developed and under evaluation.
2 = Development complete; commercial production initiated, but distribution may be restricted; mail order purchase.
3 = Fully developed; limited use, not locally available; mail order purchase likely.
4 = Fully developed; limited use, available from local plumbing supply houses or hardware stores.
5 = Fully developed; widespread use, available from local plumbing supply houses or hardware stores.

5.2.2.3 Clotheswashing Devices and Systems

The operation of conventional clotheswashers consumes varying quantities of water depending on the manufacturer and model of the washer and the cycle selected. For most, water usage is 23 to 53 gal (87 to 201 l) per usage. Based on home water use monitoring, an average water use/wastewater flow volume of approximately 37 gal (140 l) per use has been identified, with the clotheswasher contributing about 10.0 gpcd (38 lpcd) or 22% of the total daily water use/wastewater flow (Table 4-2). Practical methods to reduce these quantities are somewhat limited. Eliminating wasteful water use habits, such as washing with only a partial load, is one method. Front-loading model automatic washers can reduce water used for a comparable load of clothes by up to 40%. In addition, wastewater flow reductions may be accomplished through use of a clotheswasher with either adjustable cycle settings for various load sizes or a wash water recycle feature.

The wash water recycle feature is included as an optional cycle setting on several commercially made washers. Selection of the recycle feature when washing provides for storage of the wash water from the wash cycle in a nearby laundry sink or a reservoir in the bottom of the machine, for subsequent use as the wash water for the next load. The rinse cycles remain unchanged. Since the wash cycle comprises about 45% of the total water use per operation, if the wash water is recycled once, about 17 gal (64 l) will be saved, if twice, 34 gal (129 l) , and so forth. Actual water savings and wastewater flow reductions are highly dependent on the user's cycle selection.

5.2.2.4 Miscellaneous Devices and Systems

There are a number of additional devices, fixtures, and appliances available to help reduce wastewater flow volumes. These are directed primarily toward reducing the water flow rate through sink and basin faucets. Table 5-5 presents a summary of several of these additional flow reduction devices. Experience with these devices indicates that wastewater volume can be reduced by 1 to 2 gpcd (4 to 8 lpcd) when used for all sink and basin faucets.

5.2.3 Wastewater Recycle and Reuse Systems

Wastewater recycle and reuse systems collect and process the entire wastewater flow or the fractions produced by certain activities with storage for subsequent reuse. The performance requirements of any wastewater recycle system are established by the intended reuse activities. To simplify the performance requirements, most recycle

TABLE 5-5

WASTEWATER FLOW REDUCTION - MISCELLANEOUS DEVICES AND SYSTEMS

Generic Type[a]	Description	Development Stage[b]	Application Considerations
Faucet Inserts	Device which inserts into faucet valve or supply line and restricts flow rate with a fixed or pressure compensating orifice. Varieties: Many.	4	Compatible with most plumbing. Installation simple.
Faucet Aerators	Devices attached to faucet outlet which entrain air into water flow. Varieties: Many.	5	Compatible with most plumbing. Installation simple. Periodic cleaning of aerator screens.
Reduced-Flow Faucet Fixtures	Similar to conventional unit, but restrict flow rate with a fixed or pressure compensating orifice. Varieties: Many.	4	Compatible with most plumbing. Installation identical to conventional.

TABLE 5-5 (continued)

Generic Type[a]	Description	Development Stage[b]	Application Considerations
Mixing Valves	Specifically designed valve units which allow flow and temperature to be set with a single control. Varieties: Many.	5	Compatible with most plumbing. Installation identical to conventional.
Hot Water Pipe Insulation	Hot water piping is wrapped with insulation to reduce heat loss from hot water standing in pipe between uses. Varieties: Many.	4	May be difficult to retrofit.

[a] No reduction in pollutant mass; insignificant increase in pollutant concentration.

[b] 1 = Prototypes developed and under evaluation.
2 = Development complete; commercial production initiated, but distribution restriced.
3 = Fully developed, limited use, not locally available; mail order purchase likely.
4 = Fully developed, limited use, locally available from plumbing supply houses or hardware stores.
5 = Fully developed, widespread use, locally available from plumbing supply houses or hardware stores.

systems process only the wastewaters discharged from bathing, laundry, and bathroom sink usage, and restrict the use of the recycled water to flushing water-carriage toilets and possibly lawn irrigation. At the other extreme, systems are under development that process the entire wastewater flow and recycle it as a potable water source.

The flow sheets proposed for residential recycle systems are numerous and varied, and typically employ various combinations of the unit processes described in Chapter 6, complemented by specially designed control networks. In Table 5-6, several generic units are characterized according to their general recycle flow sheet.

5.3 Pollutant Mass Reduction

A second strategy for wastewater modification is directed toward decreasing the mass of potential pollutants at the source. This may involve the complete elimination of the pollutant mass contributed by a given activity or the isolation of the pollutant mass in a concentrated wastewater stream. In Table 5-7, several methods for pollutant mass reduction are outlined.

5.3.1 Improved User Habits

Unnecessary quantities of many pollutants enter the wastewater stream when materials, which could be readily disposed of in a solid waste form, are added to the wastewater stream. A few examples include flushing disposable diapers or sanitary napkins down the toilet, or using hot water and detergents to remove quantities of solidified grease and food debris from pots and pans to enable their discharge down the sink drain.

5.3.2 Cleaning Agent Selection

The use of certain cleansing agents can contribute significant quantities of pollutants. In particular, cleaning activities, such as clotheswashing and dishwashing, can account for over 70% of the phosphorus in residential wastewater (Table 4-4). Detergents are readily available that contain a low amount of phosphorus compared to other detergents.

TABLE 5-6

WASTEWATER FLOW REDUCTION - WASTEWATER RECYCLE AND REUSE SYSTEMS

Flow Sheet Description	Development Stage[a]	Application Considerations	Operation and Maintenance	Total Flow Reduction[b] gpcd	%	Wastewater Quality Impacts
Recycle bath and laundry for toilet flushing	2	Requires separate toilet supply and drain line. May be difficult to retrofit to multi-story building. Requries wastewater disposal system for toilet and kitchen sink wastes.	Periodic replenishment of chemicals, cleaning of filters and storage tanks. Residuals disposal. Power use.	16	36	Sizable removals of pollutants, primarily P.
Recycle portion of total wastewater stream for toilet flushing	3	Requires separate toilet supply line. May be difficult to retrofit to multi-story building. Requires disposal system for unused recycle water.	Cleaning/replacement of filters and other treatment and storage components. Residuals disposal. Periodic replenishment of chemicals.	16	36	Significant removals of pollutants.

TABLE 5-6 (continued)

Flow Sheet Description	Development Stage[a]	Application Considerations	Operation and Maintenance	Total Flow Reduction[b] gpcd	Total Flow Reduction[b] %	Wastewater Quality Impacts
Recycle toilet wastewaters for flushing water carriage toilets	4	Requires separate toilet plumbing network. Utilizes low-flush toilets. Requires system for nontoilet wastewaters. May be difficult to retrofit. Application restricted to high use on multi-unit installations.	Cleaning/replacement of filters and other treatment components. Residuals disposal. Power use.	16	36	Significant removals of pollutants.
Recycle total wastewater stream for all water uses	1-2	Requires major variance from State/local health codes for potable reuse. Difficult to retrofit.	All maintenance by skilled personnel. Routine service check. Periodic pump out and residuals disposal. Power use. Comprehensive monitoring program required.	45	100	No wastewater generated for onsite disposal.

[a] 1 = Prototype developed and under evaluation.
2 = Development complete; commercial production initiated, but distribution may be restricted.
3 = Fully developed; limited use, not locally available, mail order purchase likely.
4 = Fully developed; limited use, locally available from plumbing supply houses and hardware stores.
5 = Fully developed; widespread use, locally available from plumbing supply houses and hardware stores.

[b] Based on the normal waste flow information presented in Table 4-2.

TABLE 5-7

EXAMPLE POLLUTANT MASS REDUCTION METHODS

I. Improved User Habits

II. Cleaning Agent Selection

III. Elimination of Garbage Disposal Appliance

IV. Segregated Toilet Systems

   A. Non-Water Carriage Toilets
   B. Very Low-Volume Flush Toilets/Holding Tank
   C. Closed Loop Wastewater Recycle Systems

5.3.3 Elimination of the Garbage Disposal Appliance

The use of a garbage disposal contributes substantial quantities of BOD_5 and suspended solids to the wastewater load (Table 4-4). As a result, it has been shown that the use of a garbage disposal may increase the rate of sludge and scum accumulation and produce a higher failure rate for conventional disposal systems under otherwise comparable conditions (6). For these reasons, as well as the fact that most waste handled by a garbage disposal could be handled as solid wastes, the elimination of this appliance is advisable.

5.3.4 Segregated Toilet Systems

Several toilet systems can be used to provide for segregation and separate handling of human excreta (often referred to as blackwater) and, in some cases, garbage wastes. Removal of human excreta from the wastewater stream serves to eliminate significant quantities of pollutants, particularly suspended solids, nitrogen, and pathogenic organisms (Table 4-4).

A number of potential strategies for management of segregated human excreta are presented in Figure 5-1. A discussion of the toilet systems themselves is presented in the wastewater flow reduction section of this chapter, while details regarding the other unit processes in the flow sheet may be found in Chapter 6.

Wastewaters generated by fixtures other than toilets are often referred to collectively as "graywater." Characterization studies have demonstrated that typical graywater contains appreciable quantities of organic matter, suspended solids, phosphorus and grease in a daily flow volume of 29 gpcd (110 lpcd) (7)(8)(9)(10)(11)(12)(13)(14)(15) (see Table 4-4). Its temperature as it leaves the residence is in the range of 31° C, with a pH slightly on the alkaline side. The organic materials in graywater appear to degrade at a rate not significantly different from those in combined residential wastewater (15). Microbiological studies have demonstrated that significant concentrations of indicator organisms as total and fecal coliforms are typically found in graywater (7)(11)(12)(13)(14)(15). One should assume, therefore, that graywater harbors pathogens.

Although residential graywater does contain pollutants and must be properly managed, graywater may be simpler to manage than total residential wastewater due to a reduced flow volume. While diverse strategies have been proposed for graywater management (Figure 5-2), rigorous field evaluations have not been conducted in most cases. Until further field data become available, it is recommended that graywater treatment and disposal/reuse systems be designed as for typical residential wastewater (as described in Chapter 6). Design allowances should be made only for the reductions in flow volume, as compared to typical residential wastewater.

5.4 Onsite Containment - Holding Tanks

Wastewaters may be contained on site using holding tanks, and then transported off site for subsequent treatment and disposal. In many respects, the design, installation, and operation of a holding tank is similar to that for a septic tank (as described in Chapter 6). Several additional considerations do exist, as indicated in Table 5-8. A discussion regarding the disposal of the pumpage from holding tanks is presented in Chapter 9 of this manual.

5.5 Reliability

An important aspect of wastewater modification concerns the reliability of a given method to yield a projected modification at a specific dwelling or establishment over the long term. This is of particular importance when designing an onsite wastewater disposal system based on modified wastewater characteristics.

FIGURE 5-1

EXAMPLE STRATEGIES FOR MANAGEMENT OF SEGREGATED HUMAN WASTES

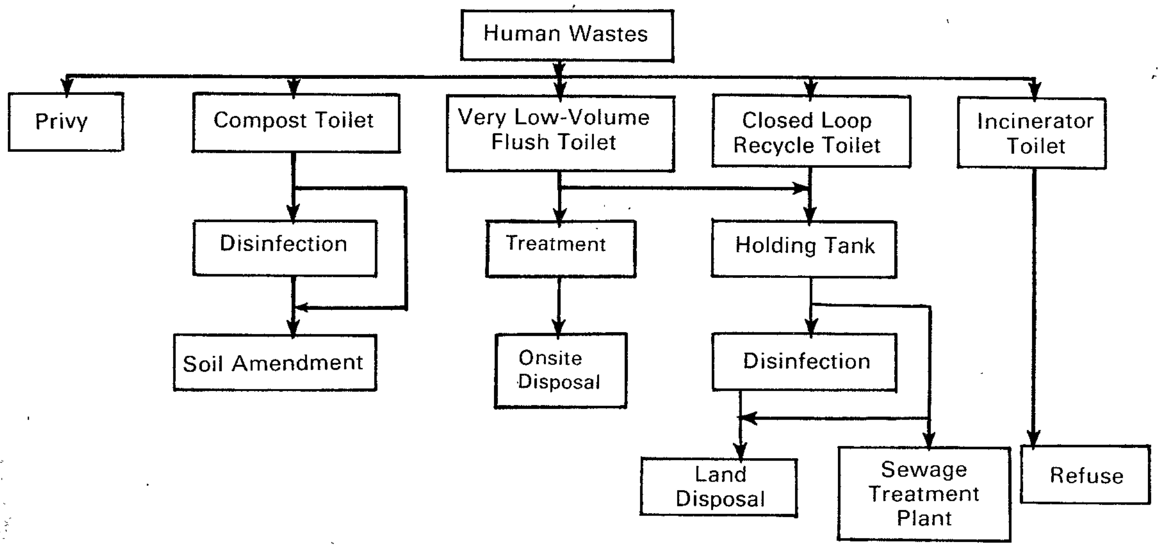


FIGURE 5-2

EXAMPLE STRATEGIES FOR MANAGEMENT OF RESIDENTIAL GRAYWATER

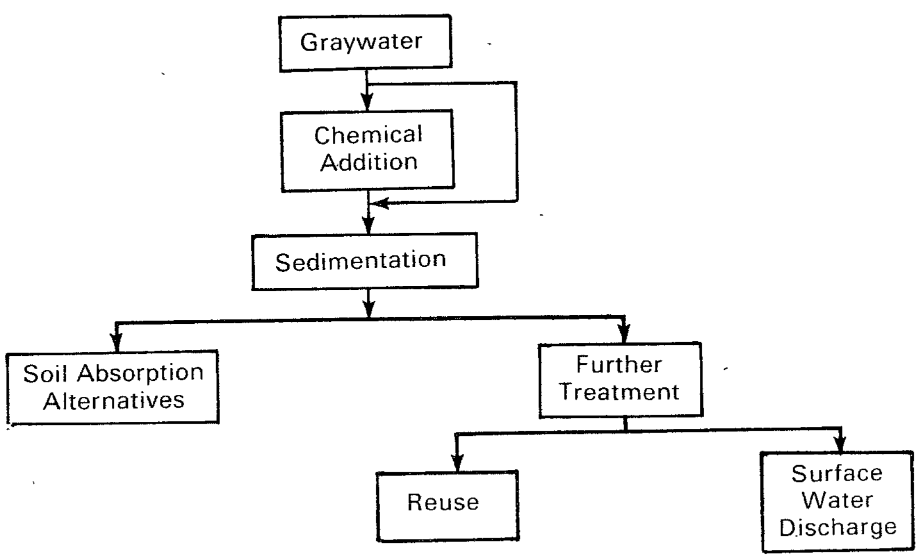


TABLE 5-8

ADDITIONAL CONSIDERATIONS IN THE DESIGN, INSTALLATION, AND OPERATION OF HOLDING TANKS

Item	Consideration
Sizing	Liquid holding capacity >7 days wastewater flow generation. Minimum capacity = 1,000 gallons.
Discharge	There should be no discharge.
Alarm System	High water alarm positioned to allow at least 3 days storage after activation.
Accessibility	Frequent pumping is likely; therefore holding tank(s) must be readily accessible to pumping vehicle.
Flotation	Large tanks may be subject to severe flotation forces in high groundwater areas when pumped.
Cost	Frequent pumping and residuals disposal results in very high operating costs.

Assessing the reliability of wastewater modification methods is a complex task which includes considerations of a technological, sociological, economic, and institutional nature. Major factors affecting reliability include:

1. The actual wastewater characteristics prior to modification compared to the average.
2. User awareness and influence on method performance.
3. Installation.
4. Method performance.
5. User circumvention or removal.

In most situations, projections of the impact of a wastewater modification method must necessarily be made, assuming the wastewater characteristics prior to modification are reasonably typical. If the actual wastewater characteristics deviate significantly from that of the average, a projected modification may be inaccurate.

The prospective user should be fully aware of the characteristics of a method considered for use prior to its application. Users who become aware of the characteristics of a method only after it has been put into use are more likely to be dissatisfied and attempt to circumvent or otherwise alter the method and negate the wastewater modification expected.

In general, passive wastewater modification methods or devices not significantly affected by user habits tend to be more reliable than those which are subject to user habits and require a preconceived active role by the users. For example, a low-flush toilet is a passive device, while a flow-reducing shower head is an active one.

Installation of any devices or systems should be made by qualified personnel. In many situations, a post-installation inspection is recommended to ensure proper functioning of the device or system.

Method performance is extremely important in assessing the reliability of the projected modification. Accurate performance data are necessary to estimate the magnitude of the reduction, and to predict the likelihood that the method will receive long-term user acceptance. Accurate performance data can only be obtained through the results of field testing and evaluations. Since many methods and system components are presently in various stages of development, only preliminary or projected operation and performance data may be available. This preliminary or projected data should be considered cautiously.

The continued employment of a wastewater modification method can be encouraged through several management actions. First, the user(s) should be made fully aware of the potential consequences if they should discontinue employing the modification method (e.g., system failure, water pollution, rejuvenation costs, etc.). Also, the appropriate management authority can approve only those methods whose characteristics and merits indicate a potential for long-term user acceptance. Further, installation of a device or system can be made in such a manner as to discourage disconnection or replacement. Finally, periodic inspections by a local inspector within the framework of a sanitary district or the like may serve to identify plumbing alterations; corrective orders could then be issued.

To help ensure that a projected modification will actually be realized at a given site, efforts can be expended to accomplish the following tasks:

1. Confirm that the actual wastewater characteristics prior to modification are typical.
2. Make the prospective user(s) of the modification method fully aware of the characteristics of the method, including its operation, maintenance, and costs.
3. Determine if the projected performance of a given method has been confirmed through actual field evaluations.
4. Ensure that any devices or systems are installed properly by competent personnel.
5. Prevent user removal or circumvention of devices, systems, or methods.

5.6 Impacts on Onsite Treatment and Disposal Practices

5.6.1 Modified Wastewater Characteristics

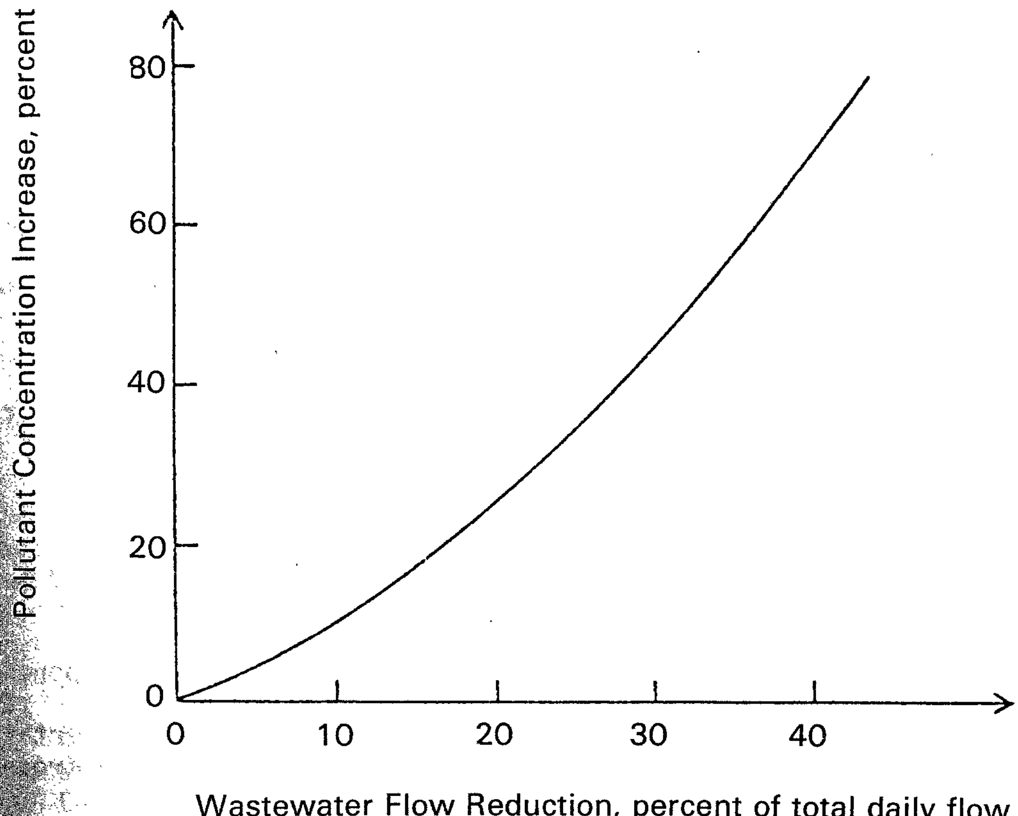
Reducing the household wastewater flow volume without reducing the mass of pollutants contributed will increase the concentration of pollutants in the wastewater stream. The increase in concentrations will likely be insignificant for most flow reduction devices with the exception of those producing flow reductions of 20% or more. The increase in pollutant concentrations in any case may be estimated utilizing Figure 5-3.

5.6.2 Wastewater Treatment and Disposal Practices

In Table 5-9, a brief summary of several potential impacts that wastewater modification may have on onsite disposal practices is presented. It must be emphasized that the benefits derived from wastewater modification are potentially significant. Wastewater modification methods, particularly wastewater flow reduction, should be considered an integral part of any onsite wastewater disposal system.

FIGURE 5-3

FLOW REDUCTION EFFECTS ON POLLUTANT CONCENTRATIONS



(Assumes Pollutant Contributions the Same
Under the Reduced Flow Volume)

TABLE 5-9

POTENTIAL IMPACTS OF WASTEWATER MODIFICATION ON ONSITE DISPOSAL PRACTICES

Disposal System Type	Modification Practice: Flow Reduction	Modification Practice: Pollutant Reduction	Potential Impact
All Disposal	X	X	May extend service life of functioning system, but cannot quantify.
		X	Reduce water resource contamination.
		X	Simplify site constraints.
		X	Reduce frequency of septic tank pumping.
	X		Reduce sizing of infiltrative area.
	X		Remedy hydraulically overloaded system.
Surface Disposal	X	X	Reduce component O and M costs.
	X	X	Reduce sizing of components.
		X	Eliminate need for certain components (e.g., nitrogen removal).
	X		Remedy hydraulically overloaded system.
Evapotranspiration	X		Remedy a hydraulically overloaded system.
	X		Reduce sizing of ET area.
Onsite Containment	X		Reduce frequency of pumping.
	X		Reduce sizing of containment basin.

5.7 References

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